CLEANING UP

The INEEL used to flush wastewater containing organic cleaning solvents and radionuclides directly into the Aquifer. During the 1960s, DOE dumped thousands of barrels of plutonium-contaminated waste from Colorado's Rocky Flats nuclear weapons plant into unlined pits at the INEEL. Leaks from transfer lines released highly radioactive material into the soil at the INTEC tank farm.

These poor management practices have been stopped, and EPA and Idaho's DEQ now make sure DOE complies with environmental laws passed in the 1980s. Under federal law, DOE polices itself when it comes to managing radioactive materials.

Nevertheless, DOE must still address the contamination created by its historic activities. Ten years ago, EPA added the INEEL to the Superfund National Priority List. In 1991, DOE signed an agreement with EPA and the State of Idaho to establish a process for cleaning up contaminated sites. Under the agreement, the agencies evaluate how much and what kind of contamination is present, as well as the types of threats posed. They study different methods for reducing potential risks, develop a range of options on which to receive feedback from the public, and then decide what actions are appropriate.

The Agreement, called the "Federal Facilities Agreement and Consent Order," is referred to as the FFA/CO. Idaho's DEQ oversees activities carried out under the agreement.

The goal of cleanup is to reduce risks posed by contaminated areas to an acceptable level. It's virtually impossible to put the INEEL exactly back the way it was before the federal government started using it back in 1949, so the agencies evaluate how to cost-effectively reduce threats to human health and the environment, depending on the type and amount of contamination.

In some cases, that involves digging up contaminated material for treatment and/or disposal at facilities designed to protect health and the environment. In others, that means sealing off the routes through which contamination can reach the environment. And some radioactive contamination converts into nonradioactive material in a short enough time period to be safely managed by restricting access. The agencies may also decide that some contaminated areas do not pose an undue threat to human health and the environment and do not require any action.

The INEEL is divided into ten Waste Area Groups (WAGs). Cleanup decisions have been made for several of the WAGs. Cleanup of buried waste at the Radioactive Waste Management Complex, highly radioactive contamination at the Idaho Nuclear Engineering and Technology Center's tank farm, and contaminated groundwater all pose technical and budgetary challenges.

Underneath Test Area North at INEEL, billions of workers are cleaning up groundwater contaminated with solvents injected into a well years ago. Luckily they're not on the payroll, and they don't require medical benefits. All they need is a little fertilizer and a steady "diet" of pollutants.

How does a breakfast of gasoline sound? Or a luncheon of trichloroethylene? If you can read this, such a diet would be lethal. For certain microbes, however, it is fine fare indeed. One creature's hazardous waste is another creature's sumptuous feast. And therein lies a big part of the future of groundwater cleanup at INEEL.

It's called bioremediation: the use of microorganisms to break down organic contaminants into less hazardous or even harmless compounds.

Microbes, also known as bacteria, are the earth's ultimate recyclers. Their role in the ecosystem is basically to recycle the components of life. When living things die, microbial action breaks them down into component elements of water, carbon, nitrogen, phosphorus and trace elements. Eventually these elements will be available to recombine with other materials, perhaps in new life forms.

Pollutants, too, will pass. The process may be relatively quick, as with the radioactive decay of tritium, or slow, as with the six billion-year half-life of Uranium-238. Leaving pollution alone and letting nature take its course is called *natural attenuation*. Sometimes this is the only cleanup option. Nothing can be done to reduce radioactivity except wait—in some cases for billions of years.

The breakdown of many pollutants, however, can be hustled along considerably. Organic contaminants—those containing carbon—and some metals can be neutralized by microorganisms living naturally in the soil. *Biodegradation* refers to the chemical transformations induced in organic contaminants by these microorganisms as they eat, detoxify their environment, or perform other operations necessary to live and reproduce.

In situ bioremediation treats contamination without moving it (in situ is Latin for "in the original place") by encouraging the growth and reproduction of these organisms. Microbial activity in the soil depends on a variety of factors. Generally the soil must be between 60 and 110 degrees Fahrenheit, and must not be too alkaline or acidic (pH between 5.5 and 8.5). All bacteria need nutrients—nitrogen, phosphorus, and others—and some (*aerobic* bacteria) require oxygen while others do not (*anaerobic*). When conditions are right, microbial activity flourishes, and organic contaminants transform into more benign compounds.

At Test Area North, a plume of groundwater contamination stretches roughly two miles from the original well where pollutants were injected

Cleanup remedies are a fascinating mixture of sophisticated technology and common-sense actions. The cleanup at TAN uses both.

The bioremediation is on the sophisticated side of the technology spectrum. But an air stripper, technology that has been used for decades, is also in use; as is natural attenuation, which has been going on for millions of years. A matter of letting nature do its work, natural attenuation now accepted, under strict conditions, by the EPA and some states. Monitoring is required.

There are three reasons natural attenuation is used: because it is cost-effective, because resources can be focused on problems that pose the most risk, and because it works.

The photos to the right were taken at TAN. Top, installation of water lines to connect extraction wells to an air stripper. Next, the interior of a new building which houses the air stripper, followed by a photo of the control panel and extraction well. Photos of a surge tank inside new structure and the control panel inside new structure complete the sequence.

into the aquifer from 1953 to 1972. The contamination is composed primarily of organic solvents like perchloroethylene, or perc, and trichloroethylene (TCE). These solvents work well to clean grease from machine parts, but you don't want them in your drinking water, where they can cause rashes, sore throats, vomiting, heart problems and perhaps even cancer. (The recent bestseller *A Civil Action*, made into a movie starring John Travolta, recounted the true story of the health problems caused by TCE-contaminated wells in Woburn, Massachusetts.) For many years DOE has been pumping the contaminated water out of the aquifer, treating it until it meets water quality standards, then reinjecting it into ground. In the last year, however, bioremediation has replaced "pump and treat" as the preferred approach at the "hot spot," the site of the original injection well.

Now INEEL scientists are injecting sodium lactate, a food-grade milk product, into the well to stimulate the growth of indigenous microbial colonies. The milk "feeds" the bacteria while the microbes "breathe" chlorine atoms, transforming perc into TCE, then dichloroethylene, and eventually into relatively harmless ethane gas. Once metabolized by the microbes, the free chlorine atoms pose no threat to groundwater quality. In theory this should make a safe, effective and cheap way to treat groundwater at INEEL and elsewhere.

So far, bioremediation seems to be working just the way scientists believed it would. Although it will take several years for the method to be proven effective at TAN, the early evidence is highly encouraging. Hydrogeologist Mark Jeffers of the Idaho Department of Environmental Quality says that bioremediation is "emerging as an innovative technology for effectively remediating groundwater." Jeffers adds that the TAN project is "absolutely cutting edge" in applying the technique to an aquifer composed of fractured basalt.

Like the technologies used at TAN, those used at the Test Reactor Area blend the old with the new. Simple methods like putting the contaminated soil in one place instead of leaving it scattered around and putting big rocks on top to keep people out are used, along with a complex engineered "biobarrier."

After Test Reactor Area percolation ponds were closed down, soil from all over the facility was moved into the now-empty ponds (first and second pictures.)

Then an engineered "biobarrier" was installed to keep live things from coming into contact with the contaminated soil. Water can pass through the barrier, but living things can't. Special attention was paid to harvester ants. Even they can't go through the barrier.

Completed, the barrier looks like a pile of rocks. And, in part, it is. The boulders on top are to deter people from getting to the soil. And indeed, someone would have to be pretty determined, and have a lot of earth-moving equipment to get through the barrier. Installation of the "biobarrier" is shown in the third and fourth pictures, and a close-up of the barrier in the fifth.

WAG	What are the significant issues?	Status
1 Test Area North	Underneath TAN, there are roughly two miles of groundwater contaminated primarily with organic cleaning solvents injected into the Aquifer until 1972. Cleanup of TAN will also address soils and wastewater ponds contaminated with metals, radionuclides and organics.	In-situ bioremediation—using microorganisms to convert groundwater contaminants into non-hazardous compounds—has been determined to be a more effective treatment than conventional pump-and-treat technology. At the hot spot—the original injection well at TAN—treatment has focused on injecting sodium lactate to help the bacteria grow and accelerate their degradation of trichloroethylene (TCE). The pump-and-treat operation has moved to the less-contaminated "medial zone." At the far reaches of the plume, the "distal zone" where contamination is least, natural attenuation will do the trick.
2 Test Reactor Area	The cleanup of TRA is relatively straightforward. It will address soils contaminated with radionuclides, heavy metals and organics.	Remediation of TRA was completed in late 1999, ahead of schedule and under budget. An underground biobarrier was installed to keep insects and burrowing animals from getting to contaminants and bringing them up to the surface. Groundwater monitoring continues. In short, the 1993 Record of Decision is being implemented successfully.
3 Idaho Nuclear Engineering and Technology Center	Cleanup will address groundwater and soil contamination (heavy metals, organics and radionuclides) from wastewater disposal ponds, facility operations and an injection well. The agencies have proposed to take contaminated wastewater ponds out of service and to construct an on-site RCRA-compliant disposal facility for contaminated soils and debris in and adjacent to the ponds. The agencies would agree on design and waste acceptance criteria before approving such a facility. Some material would still have to be disposed of off-site. Because of the complexity of the cleanup of highly radioactive spills from tank farm transfer lines, additional studies are being conducted in this area.	The agencies are in the early phase of design for construction of an on-site RCRA-compliant disposal facility. The siting process is nearing completion. A remedial investigation work plan for the tank farm is under review. An interim action is planned to seal the surface of the tank farm with a polyurethane-like coating to prevent infiltration of surface water into the tank area. The agencies are currently in the design phase for all 7 remedial action groups, per a Record of Decision issued in September of 1999.
4 Central Facilities Area	Three sites have been determined to pose unacceptable risks, and have thus been slated for cleanup: a wastewater pond contaminated with mercury, a drainfield containing Cesium-137, and a transformer yard contaminated with lead.	A Record of Decision was signed in July of 2000, so the agencies have settled on cleanup methods for the three sites. The pond will be excavated and the contaminated soils may be disposed at the proposed soils disposal facility at INTEC. The cesium-laced drainfield will be capped, and the leaden soils of the transformer yard will be removed and disposed at a facility in Utah.
5 Power Burst Facility/ Auxiliary Reactor Area	Cleanup of these facilities will address tank sites, soils and wastewater ponds contaminated with radionuclides, heavy metals and organics.	The Record of Decision for this area was finalized in January of 2000, and the cleanup is on a fast track. Phase I will tackle the tank sites. Remedial design has been completed, sampling to support the design has begun, and the process of identifying a facility to treat the radioactive

WAG	What are the significant issues?	Status
5 Power Burst Facility/ Auxiliary Reactor Area (continued)		(continued from previous page) waste is underway. The final inspection of Phase I cleanup is scheduled for summer of 2001. Phase II will treat the contaminated soil sites. The design phase of this project began in July 2000, with fieldwork to be completed by June 2004.
6	WAG 6 operations have been rolled into those for WAG 10.	
7 Radioactive Waste Management Complex	Most cleanup at this facility involves contamination from an 88-acre landfill in which DOE disposed of various types of waste over a 30-year period. The cleanup of **Pit 9**, an acre at the landfill containing mostly transuranic waste from weapons production at the Rocky Flats Plant in Colorado, is well behind schedule. The Pit 9 project was intended to provide information on retrieval and physical, thermal and chemical treatment technologies to support decisions on landfill cleanup. Originally, Pit 9 was a single-phase project with full-scale facilities. The original contract failed. The agencies will also evaluate whether the Advanced Mixed Waste Treatment Project can be used to treat some of the buried waste. Under the Pit 9 Record of Decision, radioactive material below 10 nanocuries may be “reburied” in Pit 9, if DOE can demonstrate to EPA and DEQ that the pit cover and liner are adequate to protect human health and the environment. Since 1996, DOE has been using vacuum pumps to remove and destroy volatile organic compounds from the zone between the ground surface and the Snake River Plain Aquifer. More than 50,000 pounds of the organic compounds in vapor form have been extracted, but the extraction equipment has had mechanical problems. The agencies are planning more wells to determine to what depth organic vapor contamination has spread.	A three-stage approach to cleaning up Pit 9 has begun. Stage 1, subsurface exploration and characterization, is well underway, with the first 20 probes finished in December, 1999. Preliminary results suggest that the highly-contaminated waste seems to be concentrated in hot spots rather than dispersed throughout the site. During stage 2, limited excavation and retrieval, these hot spots can be targeted, saving time and money. Stage 3 will entail full-scale remediation of the site. Underneath RWMC, there are still volatile organic vapors in the zone between ground level and the aquifer. These are being pumped out of the ground and burned. DOE and DEQ are also exploring new technologies for immobilizing waste in the soil before it can travel to the aquifer: in situ vitrification—using superheated probes to bake the soil into a glassy substance—and in situ grouting—injecting grout into the soil to trap contamination in solid blocks.
		Cleanup activities continue; several sites have been completed. The agencies continue to excavate contaminated soils and debris, as detailed in the 1998 Record of Decision. The soils will be consolidated for disposal and capped at the NRF.
9 Argonne National Laboratory West	Argonne cleanup must address cesium-contaminated soils and wastewater ponds. DOE is conducting a two-year test at Argonne to see whether it can use plants to uptake cesium from the soils, thereby eliminating the need for digging up soils and disposing of them elsewhere.	At this site, phytoremediation—cleanup through plant uptake—of contaminated soils continues as scheduled. Koshia weeds are taking up cesium 137, while willows are drawing chromium and other metals from the soil. The plants have been harvested and analyzed to determine how much radioactivity and metals they have removed from the soil in order to determine if phytoremediation will continue.
10 Miscellaneous Sites; Snake River Plain Aquifer	Includes: cleanup of unexploded shells from when the Navy used the INEEL as a practice firing range for its artillery; site groundwater quality; overall site ecorisk; and miscellaneous sites such as the Organic Moderated Reactor Experiment and the old Security Training Facility. DOE has cleaned up known range locations, but continues to look for shells as it investigates other locations.	The agencies are conducting investigations and expect to make cleanup decisions for these sites in 2002.